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EXAMINER	
RUGGLES, JOHN S	
ART UNIT	**PAPER NUMBER**
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DATE MAILED: 08/16/2004

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary	Application No.	Applicant(s)
	09/966,080	KAMIJIMA ET AL.
	Examiner	Art Unit
	John Ruggles	1756

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *14 July 2004*.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1,2 and 4-47* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1,2 and 4-47* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☒ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☒ All b)☐ Some * c)☐ None of:

1.☒ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08) Paper No(s)/Mail Date _____.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____.
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other: _____.

DETAILED ACTION

Claim 3 remains cancelled and claims 12, 17, 20, 23, 26-27, 30, 33, 36, 40, and 43 have been currently amended. Therefore, only claims 1-2 and 4-47 remain under consideration.

Claim Objections

The current amendment to the claims has overcome the previous objection of claims 17-20, which is now withdrawn. The correction of additional informalities in claims 12, 20, 23, 26-27, 30, 33, 36, 40, and 43 is also noted and appreciated.

Claim Rejections - 35 USC § 103

The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

Claims 1-2, 4, 13, and 44-45 are rejected under 35 U.S.C. 103(a) as being unpatentable over Kodama, et al. (US Patent 5,470,491) in view of Auda, et al. (US Patent 5,139,904) and further in view of Krounbi, et al. (US Patent 5,604,073).

Kodama teaches a method for manufacturing (method for fabricating) a thin film magnetic head (instant claim 45, micro device, instant claim 44) by photomechanical lithographic patterning of a thin film using a photoresist or resist pattern (instant claim 13) at column 1 lines 14-28 and 43-44. The resist pattern (analogous to the instant pre-resist pattern

formed by exposing and developing) is used as an etching mask during etching (analogous to ashing or ash-treating) of an underlying layer with a plasma of oxygen (O_2) and a freon (CF_4, SF_6, and/or CHF_3, column 2 lines 34-39). During subsequent ashing of the patterned resist with an O_2 plasma, the rate of etching or ashing of the resist is at least 10 times as fast as that of the underlying silicone resin layer, which is etched through the patterned resist (column 8 lines 31-35). Therefore, the etching or ashing treatment necessarily involves integral shrinking or narrowing of the photoresist pattern while etching (analogous to ashing of the instant pre-resist pattern carried out by using a process gas composed of O_2 and at least one of a fluorine (F) based gas and a nitrogen (N_2)/hydrogen (H_2) gas mixture). Subsequent ashing to remove the remaining resist is either by O_2 plasma alone (Example 1, column 8 lines 31-32) or by O_2 plasma with additional ion beam ashing (Example 3, column 9 line 62 to column 10 line 24). At column 10 lines 25-31, Kodama states that the additional ashing by ion beam offers the advantage that the profile of the patterned surface of the resist is transferred faithfully into the silicone surface (which is the underlying layer being etched through the photoresist etching mask).

While teaching that the first etching or ashing step includes etching of the photoresist pattern (analogous to the instant pre-resist pattern) along with etching of the underlying layer using a plasma of O_2 and a F-based freon gas, then further ashing to remove the remaining photoresist pattern either by O_2 plasma alone or by O_2 plasma with additional ion beam ashing, Kodama does not specifically teach *[1]* that the patterned photoresist is narrowed or trimmed by a first etching or ashing and then subsequently used as an etching mask in a separate additional etching step. Also, Kodama does not teach *[2]* forming a polymethylglutarimide (PMGI) layer

between the substrate and the photoresist pattern with subsequent partial removal of the PMGI by an alkaline water solution (bilayer resist process).

However, it has been known for some time in the art of photolithography to further narrow or trim a resist that has already been patterned prior to subsequent etching through the narrowed or trimmed resist pattern of an underlying layer, particularly in order to form narrower etched features in the underlying layer than would be permitted by optical patterning alone of the resist (due to optical resolution limits). For example, Auda (issued in 1992) shows a process in which a patterned resist 17a in Figure 2B is simultaneously isotropically thinned and narrowed in a standard plasma tool by reactive ion etching (RIE) to a narrowed resist pattern 17a' in Figure 2C, then anisotropic etching through the narrowed resist pattern of an underlying layer 16 using a different RIE tool to leave only underlying layer portion 16a in Figure 2D (abstract, column 5 line 30 to column 6 line 17, *[1]*). A primary object of the Auda process is to produce high resolution and reproducible patterns with standard photoresist compositions and conventional UV photolithography equipment, beyond the definition that is normally available with this equipment (which means that the resolution of etched patterns is extended to smaller dimensions by further etching of the resist after initial photolithographic patterning to narrow the patterned resist below the resolution limit of the photolithography equipment, column 4 lines 3-8).

Krounbi discloses a bilayer lift-off photolithographic process for making lead conductors in a magnetoresistive (MR) sensor at column 3 lines 36-38. A polydimethylglutarimide (PMGI) release layer with an adhesion promoter additive is coated on a substrate, followed by overcoating with a diazonapthoquinone (DNQ)/Novolac (napthoquinonediazide/novolac) positive resist which is then exposed to the desired pattern and developed (as a bilayer resist

process). During developing, the PMGI release layer is undercut from the edges of the resist pattern by an aqueous base developer (alkaline water solution, column 3 lines 20-21, instant claim 4) to facilitate subsequent lift-off (column 1 lines 27-39). A long undercut provides the most effective lift-off (column 3 line 44). At column 2 lines 24-28, Krounbi states that bilayer lift-off processes are known in the art for producing well-defined patterns on a substrate surface using deposition techniques. Figures 1-4 as described at column 2 lines 29-47 show the process steps of developing the resist pattern (which includes undercutting of the PMGI release layer), overcoating (layer 6 in Figure 3), and subsequent lift-off of the bilayer resist pattern by dissolving the PMGI release layer with an aqueous alkali or organic solvent *[2]*.

It would have been obvious to one of ordinary skill in the art at the time the invention was made to employ the resist pattern narrowing technique shown by Auda in the thin film magnetic head manufacturing process taught by Kodama to reduce the resist pattern dimensions before etching of the underlying layer, which would also result in reducing the corresponding etched features in the underlying layer, as shown by Auda *[1]*. It would also have been obvious in the process of Kodama and Auda to have incorporated a bilayer lift-off photolithographic process using a release or bottom pattern layer of PMGI, partially removed during developing as disclosed by Krounbi, in order to form an undercut at the base of the narrowed resist pattern for facilitating subsequent removal of the narrowed resist pattern during lift-off. This is because the bilayer process using PMGI as the release layer is stated by Krounbi to be known in the art for producing well-defined deposition patterns on a substrate and also because a long undercut provides the most effective lift-off *[2]*.

Claim 2 is rejected under 35 U.S.C. 103(a) as being unpatentable over Kodama in view of Auda, further in view of Krounbi, and further in view of Tseng, et al. (US Patent 5,811,358).

While teaching a method for fabricating a bilayer resist pattern by photolithographic patterning and ashing of the resist over a PMGI release layer using a process gas composed of O_2 and a fluorine (F) based gas, Kodama, Auda, and Krounbi do not specify ashing using a process gas having O_2 and a nitrogen (N_2)/hydrogen (H_2) gas mixture.

Tseng shows addition of a N_2/H_2 gas mixture (ratio about 4-96% N_2/H_2) to O_2 plasma during ashing of a photoresist or resist pattern to increase the ashing efficiency at column 3 lines 4-5 and 61-66. The addition of H_2 plasma can effectively break chemical bonds in the resist to increase the reaction rate (column 4, lines 14-16).

It would have been obvious to one of ordinary skill in the art at the time the invention was made to carry out the resist ashing and etching as taught by Kodama, Auda, and Krounbi with the alternative O_2 and N_2/H_2 gas mixture shown by Tseng to increase the ashing efficiency, because addition of H_2 plasma can effectively break chemical bonds in the resist to increase the reaction rate.

Claims 5, 16, 26, and 36 are rejected under 35 U.S.C. 103(a) as being unpatentable over Kodama in view of Auda, further in view of Krounbi, further in view of Cohen et al. (US Patent 5,820,770), and further in view of Kamijima (US Patent 5,721,078).

Kodama, Auda, and Krounbi do not specifically teach forming T-shaped or reversed trapezoid profile or longitudinal cross section resist patterns and do not show subsequent milling using the resist pattern before lift-off.

Cohen shows a process of making a thin film magnetic head by: (1) metal plating through a suitable photoresist or resist mask (column 6 lines 57-58), (2) vacuum deposition (e.g., sputtering, evaporation, etc.) with subsequent etching by reactive ion etching (RIE) or ion milling (which is understood to be a sputter etching method) through a photoresist or resist mask patterned by photolithography (column 7 lines 9-26 and 47-50), or (3) forming a plug 50 (e.g., of photoresist or resist, etc.) with negative sloped walls 52 (which have an overhanging top with respect to the plug base) on a substrate (bonding pad 38) as shown in Figure 6 followed by sputtering an alumina layer 40 to leave a cap layer 40A on the plug 50, then lift-off of the cap layer 40A along with the plug 50 (photoresist or resist) by etching or stripping (column 11 line 61 to column 12 line 7). At column 12 lines 1-4, Cohen points out that because sputtering is highly directional and anisotropic, the overhang created by the negative sloped walls 52 (of the photoresist or resist pattern plug 50) leaves a gap between the lateral termination of alumina layer 40 and plug 50. Since ion milling is understood to be a sputter etching method, it would also be expected to be anisotropic and highly directional. The negative sloped walls of the plug 50 are required in order to provide accessibility of a liquid etchant or stripper to the base of the plug 50 (of patterned photoresist or resist) during subsequent lift-off (column 12 lines 10-12). Cohen also suggests the equivalency of using a negative photoresist or a negatively toned (having a negative working agent or post-treated to reverse the image) positive photoresist for the patterned plug 50 at column 12 lines 16-18. The negative sloped walls of the photoresist plug can be achieved by using a plural layer or bilayer resist process (column 12 lines 18-22). Alternatively, a metal plug having negative sloped walls can be made by plating metal through a resist pattern having an opening with positively sloped walls; the metal plug can be plated to a

thickness well beyond that of the photoresist or resist to cause the metal plug to spread or mushroom over the photoresist or resist (column 12 lines 22-30).

Kamijima teaches a magnetoresistance (MR) thin film element for a magnetic read head made by imaging or patterned exposure of a novolak (novolac) positive resist having an alkali soluble phenol resin, a naphthoquinonediazide (napthoquinonediazide), and a negative working agent (to reverse the image) at column 1 lines 12-13, column 7 line 36 to column 8 line 35, and column 13 lines 38-40. The patterned resist is treated by heating (reversal baking causes an amine salt of carboxylic acid to quickly convert into an indene insoluble in aqueous base through a carbonyl removal reaction (decarbonylation, instant [0041]), column 11 lines 10-13), uniform exposure or flood exposure, and developing to leave the imaged or exposed area, as in the case of a negative resist at column 7 lines 40-43. The resist profile or longitudinal cross-section is disclosed to be either a conventional reversed trapezoid as shown in Figures 2C-2D, 3, 5B-5C, and 8C-8E or alternatively T-shaped as shown in Figures 4, 7, and 10D, both of which are described at column 2 line 40 to column 3 line 52 and column 10 line 47 to column 11 line 40. Kamijima also points out in Figure 12 as described at column 11 line 47 to column 13 line 34 the relationship between various process conditions and the resulting resist profile. After the desired resist profile was obtained, the resist pattern was etched (by ion milling) and/or coated (by sputtering) with a thin film followed by subsequent lift-off of the resist pattern at column 14 lines 23-24 and column 15 lines 52-55.

In the art of thin film magnetic head manufacture, it would have been obvious to one of ordinary skill in the art at the time the invention was made to manufacture a T-shaped profile or longitudinal cross-section or alternative reversed trapezoid longitudinal cross-section by

patterning a bilayer resist as taught by Kodama, Auda, and Krounbi directly into either of the profiles shaped as shown by Kamijima because both of these profile shapes afford the same overhang benefit for subsequent lift-off after directional coating as shown by Cohen for a reversed trapezoid cross-section. The overhang benefit with directional coating or etching (e.g., sputter coating or etching, ion milling, etc.) is to protect the resist base region from undesired coating (to facilitate subsequent lift-off) or etching.

Claims 6-8 are rejected under 35 U.S.C. 103(a) as being unpatentable over Kodama in view of Auda, further in view of Krounbi, and further in view of either Chonan et al. (US Patent 4,444,869) or Kamijima.

Kodama, Auda, and Krounbi do not teach forming a resist pattern using a picture reversion (negative acting) photoresist or resist made by adding a negative working agent to a positive resist including a mixture of an alkaline soluble phenol resin and a napthoquinonediazide. Kodama, Auda, and Krounbi also do not show heating and uniform exposure between patterned exposing and developing of the resist.

Chonan describes a photolithographic process for forming a negative resist pattern using a positive working resist (novolak or novolac) having a phenolic hydroxyl-containing monomer or polymer (alkaline soluble phenol resin), including "naphtoquinonediazide" or napthoquinonediazide, column 2 lines 44-47 and column 3 lines 60-63). The negative resist pattern was formed by patterned exposure of the resist, heating (at 95°-150°C) to harden the exposed portion of the resist, blanket or uniform exposure to decompose the non-exposed portion of the resist, and developing the reversed resist image (using an alkaline developer suitable for

positive images) shown at column 4 line 63 to column 5 line 35 (this achieves the same result as addition of a negative working agent to the positive resist). At column 5 lines 48-53, Chonan also states that this method forms a negative resist pattern (using a positive working resist) having a high definition, equivalent to that of a positive resist image which would have been obtained by a positive working resist image formation without image reversal.

The teachings of Kamijima are discussed above.

It would have been obvious to one of ordinary skill in the art at the time the invention was made to carry out the fabricating process of Kodama, Auda, and Krounbi using the positive novolac photoresist having an alkaline soluble phenol resin and napthoquinonediazide along with heating and uniform exposure after patterned exposure as described by either Chonan or Kamijima to reverse the image (and form a negative image), because this process forms a negative resist pattern having a high definition as stated by Chonan.

Claim 9 is rejected under 35 U.S.C. 103(a) as being unpatentable over Kodama in view of Auda, further in view of Krounbi, further in view of Cohen, and further in view of either Chonan or Kamijima.

Kodama, Auda, and Krounbi do not teach forming T-shaped or reversed trapezoid profile (longitudinal cross section) resist patterns using a picture reversion (negative acting) photoresist or resist made by adding a negative working agent to a positive photoresist including a mixture of an alkaline soluble phenol resin and a napthoquinonediazide. Kodama, Auda, and Krounbi also do not show heating and uniform exposure between patterned exposing and developing of

the resist and do not show subsequent milling and/or thin film coating over the resist pattern with lift-off of the resist pattern.

The teachings of Cohen, Chonan, and Kamijima are discussed above.

It would have been obvious to one of ordinary skill in the art at the time the invention was made to carry out the fabricating process of Kodama, Auda, and Krounbi using the positive novolac photoresist having an alkaline soluble phenol resin and napthoquinonediazide along with heating and uniform exposure after patterned exposure described by either Chonan or Kamijima to reverse the image (form a negative image), because this process forms a negative resist pattern having a high definition as stated by Chonan. In the art of thin film magnetic head manufacture, it would have been obvious to one of ordinary skill in the art at the time the invention was made to manufacture a T-shaped profile (longitudinal cross-section) or alternative reversed trapezoid longitudinal cross-section by patterning a resist directly into this profile as shown by Kamijima because it affords the same overhang benefit for subsequent lift-off after directional coating as shown by Cohen for a reversed trapezoid cross-section. The overhang benefit with directional coating or etching (e.g., sputter coating or etching, ion milling, etc.) is to protect the resist base region from undesired coating (to facilitate subsequent lift-off) or etching.

Claims 10-11 are rejected under 35 U.S.C. 103(a) as being unpatentable over Kodama in view of Auda, further in view of Krounbi, and further in view of Uenishi et al. (US Patent 4,894,311).

Kodama, Auda, and Krounbi do not teach forming a resist pattern using a novolac positive photoresist including a phenol dissolution accelerator additive.

Uenishi shows a photolithographic process and a positive working photoresist or resist composition containing an alkali-soluble novolak (novolac) resin, a photosensitive compound having plural napthoquinonediazido groups, and optionally a polyhydroxy (e.g., phenol, etc.) dissolution accelerator additive for this process at column 6 lines 5-14, column 2 lines 23-35, and column 5 lines 30-48. Uenishi specifies, at column 6 lines 46-63, the advantages of photolithography using this resist composition as including the following: excellent in high resolving power, faithful reproduction, sectional shape of resist images, development latitude, and heat resistance.

It would have been obvious to one of ordinary skill in the art at the time the invention was made to fabricate a narrowed resist pattern as taught by Kodama, Auda, and Krounbi using a novolac positive resist having a photosensitive compound with plural napthoquinonediazido groups and a phenol dissolution accelerator additive as shown by Uenishi for the advantages of: high resolving power, faithful reproduction, sectional shape of resist images, development latitude, and heat resistance.

Claim 12 is rejected under 35 U.S.C. 103(a) as being unpatentable over Kodama in view of Auda, further in view of Krounbi, further in view of Cohen, further in view of Kamijima, and further in view of Uenishi.

Kodama, Auda, and Krounbi do not teach forming T-shaped or reversed trapezoid profile (longitudinal cross section) resist patterns using a novolac positive photoresist including a phenol dissolution accelerator additive. Kodama, Auda, and Krounbi also do not show subsequent milling and/or thin film coating over the resist pattern with lift-off of the resist pattern.

The teachings of Cohen, Kamijima, and Uenishi are discussed above.

In the art of thin film magnetic head manufacture, it would have been obvious to one of ordinary skill in the art at the time the invention was made to manufacture a T-shaped profile (longitudinal cross-section) or alternative reversed trapezoid longitudinal cross-section by patterning a bilayer resist as taught by Kodama, Auda, and Krounbi directly into either of the profiles shaped as shown by Kamijima because both of these profile shapes afford the same overhang benefit for subsequent lift-off after directional coating as shown by Cohen for a reversed trapezoid cross-section. The overhang benefit with directional coating or etching (e.g., sputter coating or etching, ion milling, etc.) is to protect the resist base region from undesired coating (to facilitate subsequent lift-off) or etching. It would also have been obvious to one of ordinary skill in the art at the time the invention was made to fabricate a narrowed bilayer resist pattern as taught by Kodama, Auda, and Krounbi using a novolac positive resist having a photosensitive compound with plural napthoquinonediazido groups and a phenol dissolution accelerator as shown by Uenishi for the advantages of: high resolving power, faithful reproduction, sectional shape of resist images, development latitude, and heat resistance.

Claims 14, 24, 34, and 46 are rejected under 35 U.S.C. 103(a) as being unpatentable over Kodama in view of Auda, further in view of Krounbi, and further in view of either Cohen or Kamijima.

Kodama, Auda, and Krounbi do not show subsequent milling and/or thin film coating over the resist pattern with lift-off of the resist pattern.

The teachings of Cohen and Kamijima are discussed above.

It would have been obvious to one of ordinary skill in the art at the time the invention was made to combine the narrowed bilayer resist pattern formation by ashing to make a thin film magnetic head as taught by Kodama, Auda, and Krounbi with milling and/or thin film coating by directional coating or etching (e.g., sputter coating or etching, ion milling, etc.) as taught by either Cohen or Kamijima, because bilayer resist overhang protects the resist base region from undesired coating (to facilitate subsequent lift-off) or etching.

Claims 15, 25, and 35 are rejected under 35 U.S.C. 103(a) as being unpatentable over Kodama in view of Auda, further in view of Krounbi, further in view of Cohen, and further in view of Tseng.

While Krounbi teaches forming a polymethylglutarimide (PMGI) layer between the substrate and the resist pattern with subsequent partial removal of the PMGI by an alkaline water solution (bilayer resist process) and Kodama in view of Auda and further in view of Cohen shows subsequent ashing with further milling and/or thin film coating followed by lift-off (as discussed above), they do not teach ashing by a process gas having O_2 and a nitrogen (N_2)/hydrogen (H_2) gas mixture.

The teachings of Cohen and Tseng are discussed above.

It would have been obvious to one of ordinary skill in the art at the time the invention was made to carry out the photolithographic process as shown by Kodama, Auda, Krounbi, and Cohen using resist ashing by an alternative O_2 and N_2/H_2 gas mixture shown by Tseng to increase the ashing efficiency, because addition of H_2 plasma can effectively break chemical bonds in the photoresist to increase the reaction rate.

Claims 17-18, 27-28, and 37-38 are rejected under 35 U.S.C. 103(a) as being unpatentable over Kodama in view of Auda, further in view of Cohen, and further in view of either Chonan or Kamijima.

Kodama and Auda do not teach using a picture reversion photoresist or resist made by adding a negative working agent to a positive photoresist including a mixture of an alkaline soluble phenol resin and a napthoquinonediazide and do not show heating and uniform exposure between patterned exposing and developing of the resist. Kodama and Auda also do not show subsequent milling and/or thin film coating over the resist pattern with lift-off of the resist pattern.

The teachings of Cohen, Chonan, and Kamijima are discussed above.

It would have been obvious to one of ordinary skill in the art at the time the invention was made to carry out the fabricating process of Kodama and Auda using the positive novolac photoresist having an alkaline soluble phenol resin and napthoquinonediazide along with heating and uniform exposure after patterned exposure described by either Chonan or Kamijima to reverse the image (form a negative image), because this process forms a negative resist pattern having a high definition as stated by Chonan. It would also have been obvious to use a resist profile (longitudinal cross-section) having overhang with directional coating or etching (e.g., sputter coating or etching, ion milling, etc.), because the overhang protects the resist base region from undesired coating (to facilitate subsequent lift-off) or etching as pointed out by Cohen and discussed above.

Claims 19, 29, and 39 are rejected under 35 U.S.C. 103(a) as being unpatentable over Kodama in view of Auda, further in view of Cohen, further in view of either Chonan or Kamijima, and further in view of Tseng.

While Kodama and Auda in view of either Chonan or Kamijima shows photolithographic patterning to form a narrowed resist pattern using a positive novolac photoresist having an alkaline soluble phenol resin and napthoquinonediazide along with heating and uniform exposure after patterned exposure described to reverse the image (form a negative image), then subsequent ashing with further milling and/or thin film coating followed by lift-off as taught by Cohen (as discussed above); they do not teach ashing by a process gas having O_2 and a nitrogen (N_2)/hydrogen (H_2) gas mixture.

The teachings of Cohen, Chonan, Kamijima, and Tseng are discussed above.

It would have been obvious to one of ordinary skill in the art at the time the invention was made to carry out the photolithographic process as shown by Kodama, Auda, Chonan, and Cohen using resist ashing by an alternative O_2 and N_2/H_2 gas mixture shown by Tseng to increase the ashing efficiency, because addition of H_2 plasma can effectively break chemical bonds in the photoresist to increase the reaction rate.

Claims 20, 30, and 40 are rejected under 35 U.S.C. 103(a) as being unpatentable over Kodama in view of Auda, further in view of Cohen, and further in view of either Chonan or Kamijima.

Kodama and Auda do not teach forming T-shaped or reversed trapezoid profile (longitudinal cross section) resist patterns using a picture reversion (negative acting) photoresist

made by adding a negative working agent to a positive photoresist including a mixture of an alkaline soluble phenol resin and a napthoquinonediazide. Kodama and Auda also do not show heating and uniform exposure between patterned exposing and developing of the resist and do not show subsequent milling and/or thin film coating over the resist pattern with lift-off of the resist pattern.

The teachings of Cohen, Chonan, and Kamijima are discussed above.

It would have been obvious to one of ordinary skill in the art at the time the invention was made to carry out the fabricating process of Kodama and Auda using the positive novolac photoresist having an alkaline soluble phenol resin and napthoquinonediazide along with heating and uniform exposure after patterned exposure described by either Chonan or Kamijima to reverse the image (form a negative image), because this process forms a negative resist pattern having a high definition as stated by Chonan. In the art of thin film magnetic head manufacture, it would have been obvious to one of ordinary skill in the art at the time the invention was made to manufacture a T-shaped profile (longitudinal cross-section) or alternative reversed trapezoid longitudinal cross-section by patterning a resist directly into this profile as shown by Kamijima because it affords the same overhang benefit for subsequent lift-off after directional coating as shown by Cohen for a reversed trapezoid cross-section. The overhang benefit with directional coating or etching (e.g., sputter coating or etching, ion milling, etc.) is to protect the resist base region from undesired coating (to facilitate subsequent lift-off) or etching.

Claims 21, 31, and 41 are rejected under 35 U.S.C. 103(a) as being unpatentable over Kodama in view of Auda, further in view of Cohen, and further in view of Uenishi.

While teaching fabrication of a thin film by photoresist or resist patterning and ashing followed by subsequent milling and/or thin film coating over the resist pattern with lift-off of the resist pattern, Kodama, Auda, and Cohen do not teach using a novolac positive photoresist including a phenol dissolution accelerator additive.

The teachings of Cohen and Uenishi are discussed above.

It would have been obvious to one of ordinary skill in the art at the time the invention was made to fabricate a narrowed resist pattern or patterned thin film as taught by Kodama, Auda, and Cohen using a novolac positive resist having a photosensitive compound with plural napthoquinonediazido groups and a phenol dissolution accelerator additive as shown by Uenishi for the advantages of: high resolving power, faithful reproduction, sectional shape of resist images, development latitude, and heat resistance.

Claims 22, 32, and 42 are rejected under 35 U.S.C. 103(a) as being unpatentable over Kodama in view of Auda, further in view of Cohen, further in view of Uenishi, and further in view of Tseng.

While Kodama, Auda, and Cohen teach fabricating a thin film by photoresist or resist patterning and ashing followed by subsequent milling and/or thin film coating over the resist pattern with lift-off of the resist pattern and Uenishi shows resist patterning using a novolac positive photoresist including a phenol dissolution accelerator additive, they do not show ashing by a process gas having O_2 and a nitrogen (N_2)/hydrogen (H_2) gas mixture.

The teachings of Cohen, Uenishi, and Tseng are discussed above.

It would have been obvious to one of ordinary skill in the art at the time the invention was made to carry out the photolithographic process as shown by Kodama, Auda, Cohen, and Uenishi using resist ashing by an alternative O_2 and N_2/H_2 gas mixture as shown by Tseng to increase the ashing efficiency, because addition of H_2 plasma can effectively break chemical bonds in the photoresist to increase the reaction rate.

Claims 23, 33, and 43 are rejected under 35 U.S.C. 103(a) as being unpatentable over Kodama in view of Auda, further in view of Cohen, further in view of Kamijima, and further in view of Uenishi.

Kodama and Auda do not teach forming T-shaped or reversed trapezoid profile (longitudinal cross section) resist patterns using a novolac positive photoresist including a phenol dissolution accelerator additive. Kodama and Auda also do not teach subsequent milling and/or thin film coating over the resist pattern with lift-off of the resist pattern.

The teachings of Cohen, Kamijima, and Uenishi are discussed above.

In the art of thin film magnetic head manufacture, it would have been obvious to one of ordinary skill in the art at the time the invention was made to manufacture a T-shaped profile (longitudinal cross-section) or alternative reversed trapezoid longitudinal cross-section by patterning a resist as taught by Kodama and Auda directly into either of the profiles shaped as shown by Kamijima because both of these profile shapes afford the same overhang benefit for subsequent lift-off after directional coating as shown by Cohen for a reversed trapezoid cross-section. The overhang benefit with directional coating or etching (e.g., sputter coating or etching, ion milling, etc.) is to protect the resist base region from undesired coating (to facilitate

subsequent lift-off) or etching. It would also have been obvious to one of ordinary skill in the art at the time the invention was made to fabricate a narrowed resist pattern as taught by Kodama and Auda using a novolac positive resist having a photosensitive compound with plural napthoquinonediazido groups and a phenol dissolution accelerator additive as shown by Uenishi for the advantages of: high resolving power, faithful reproduction, sectional shape of resist images, development latitude, and heat resistance.

Claim 47 is rejected under 35 U.S.C. 103(a) as being unpatentable over Kodama in view of Auda, and further in view of Uenishi.

Kodama and Auda do not teach forming a resist pattern using a novolac positive photoresist including a phenol dissolution accelerator additive.

The teachings of Uenishi are discussed above.

It would have been obvious to one of ordinary skill in the art at the time the invention was made to fabricate a narrowed resist pattern as taught by Kodama and Auda using a novolac positive resist having a photosensitive compound with plural napthoquinonediazido groups and a phenol dissolution accelerator additive as shown by Uenishi for the advantages of: high resolving power, faithful reproduction, sectional shape of resist images, development latitude, and heat resistance.

Response to Arguments

The current amendments to the claims have overcome the previous objection thereto, as well as correcting additional informalities in the claims. Therefore, the previous objection has been withdrawn, as indicated above.

Applicants' arguments with respect to the art rejections of the claims have been considered but are moot in view of the new ground(s) of rejection, which have been set forth above. Kodama teaches inherent etching or ashing to shrink or narrow the resist pattern during etching of an underlying layer (the rate of etching or ashing of the resist is taught to be at least 10 times as fast as that of the underlying silicone resin layer, which is etched through the patterned resist, column 8 lines 31-35), but does not specifically state that the narrowing of the resist pattern occurs in a separate resist pattern narrowing step before etching through the narrowed resist pattern. Therefore, Auda has now been added to more clearly show a prior separate step of etching to intentionally narrow a previously patterned resist before etching through the narrowed resist of an underlying layer in order to form smaller etched features in the underlying layer than would have been obtained without the resist pattern narrowing step. The separate narrowing of a resist pattern before etching of an underlying layer through the narrowed resist pattern as an etching mask has been known for some time as a way of extending resolution to obtain even smaller etched features in the art of photolithography than would otherwise be permitted due to optical resolution limits, as exemplified by Auda (issued in 1992) and discussed above.

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to John Ruggles whose telephone number is 571-272-1390. The examiner can normally be reached on Monday-Thursday and alternate Fridays.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Mark Huff can be reached on 571-272-1385. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9306.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

J. Ruggles

John Ruggles
Examiner
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